GROWING AND FEEDING FIELD ROOTS

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DOMINION OF CANADA
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DOMINION OF CANADA

DEPARTMENT OF AGRICULTURE

BULLETIN No. 94—NEW SERIES

50249—1

GROWING AND FEEDING FIELD ROOTS

INTRODUCTION

During the past thirty years, there has been a great increase in the use of silos, and the various crops ensiled have on many dairy and beef farms partly replaced such field roots as mangels and swedes.

However, field roots continue to hold a most important place on all live stock farms, and in consequence much recent experimental work has been conducted toward the improvement of varieties, methods of production, and determining actual costs and feeding values.

Rather than deal with the different phases of the subject in several publications, it is considered more satisfactory to combine all this material in one bulletin. The Division of Field Husbandry has contributed that section dealing with questions of soils, their treatment, cultivation, etc. The Animal Husbandry Division has prepared the chapter dealing with feeding value for farm live stock, and the Poultry Division a similar section for poultry. The Chemical section deals with nutritive values, chemical content, and the chemistry of soils and suitable fertilizers.

For full information on the question of origin, classification and distribution of varieties, seed-raising, etc., the reader is referred to a separate publication entitled "Field Roots in Canada" which deals quite fully with these subjects. There is, however, included in this Bulletin, a short section listing the types and varieties recommended for certain types of soils.

VARIETIES TO GROW*

MANGELS

Mangels as sold commercially may be divided into six general types, *i.e.* long, half-long, intermediate, ovoid, tankard, and globe. On soils that are deep, friable and rich, the long or the half-long types will give excellent yields. For average soil condition the intermediate and ovoid types are likely to be most profitable, while for shallow soils the tankard and globe types are recommended.

The following are a few of the satisfactory representatives of the different types mentioned. 1. *Long*—Long Red, Mammoth Long Red, etc. 2. *Half Long*—Half Sugar White, Half Sugar Rose, Giant Half Sugar, etc. 3. *Intermediate*—Yellow Intermediate, Danish Sludstrup, etc. 4. *Ovoid*—Yellow Ovoid, etc. 5. *Tankard*—Eclipse, Yellow Tankard, Golden Tankard, etc. 6. *Globe*—Yellow Globe, Giant Yellow Globe, Red Globe, etc.

SWEDES

While swedes have been divided into a number of different types there is not the same relationship between type and soil adaptation as exists in the case of the mangel. The varieties commonly offered for sale to the Canadian grower can be divided into the following types: Ovoid, Globe and Tankard. The globes may be spherical or flat. In all of the types the above-ground portion of the root may be coloured green, bronze or purple. The amount of pull necessary to extract these different types seems to depend more on the number and distribution of the underground roots than on the actual depth in the ground of the root itself.

Our highest yields have been secured from the round and ovoid purple-top sorts. Local conditions may warrant the growing of special types. For example in sections of the Maritime Provinces where club root is prevalent the disease-resistant Bangholm is giving profitable crops where non-resistant varieties fall down very badly in their yield due to the disease in question.

CARROTS

Field carrots may be divided into the following types: long, intermediate and short. Of the long types we have found the White Belgian and the Yellow Belgian to be quite satisfactory. Satisfactory representatives of the intermediate type are the Danish Champion and the Mammoth Intermediate white. Short types which have given promising yields in our comparative tests are the Oxheart and James.

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* From "Field Roots in Canada."

GROWING FIELD ROOTS

BY E. S. HOPKINS, B.S.A., M.S., DOMINION FIELD HUSBANDMAN

ACREAGE AND YIELDS

The total area in Canada under all classes of roots, except sugar beets, in 1911, was 208,000 acres, according to the agricultural statistics collected by the Dominion Bureau of Statistics. In 1918 the acreage rose to 325,000, but since then it has gradually decreased until in 1925 the area devoted to these crops was 204,000 acres. The average yield in the past ten years for all Canada was 9 tons per acre. On eight Dominion Experimental Stations in Eastern Canada, the average yield of roots for the past 4 years was 19.5 tons per acre. This yield was nearly twice as high as the average yield of all the roots grown in the five eastern provinces of Canada, which was but 10.5 tons per acre for the same period.

Mangels require a fertile soil for largest yields.

In 1925 Ontario produced 54 per cent of all the roots grown for forage in Canada, Quebec grew 17 per cent, New Brunswick, Nova Scotia and Prince Edward Island combined 17 per cent, the three Prairie Provinces together 9 per cent, and British Columbia 3 per cent.

CLIMATE

Mangels and carrots give highest yields in a warm or even in a hot climate, while swedes and turnips do best where the climate is cool. For maximum yields all kinds of roots require soil moisture in abundance and rainy seasons suit them best. Prolonged hot spells are very detrimental to swedes, and are disastrous if accompanied by dry weather, but mangels after the first two months of growth will withstand drought better than any other root crop.

SOIL

Roots will grow successfully on almost any kind of soil that is deep, fertile and well drained. Mangels do particularly well on loams and black muck areas, swedes and turnips prefer a clay loam and carrots are best adapted to sand or sandy loam. Mangels and carrots require more fertility and better soil conditions generally than swedes and turnips.

PREPARATION OF LAND

In some sections of the Dominion, and particularly in Eastern Canada, roots form a considerable part of the cultivated crops of the farm rotations. As a rule four or five years should elapse before the same or related crop is grown on the same piece of land or otherwise the crops may suffer from insect or disease ravage.

Late summer or fall ploughing and thorough spring seed-bed preparation is desirable for roots.

Roots usually follow sod and they do best after a clover sod. The sod should be ploughed if possible in the late summer, turning a shallow flat furrow, cultivated during the fall and ribbed up or reploughed fairly deep late in the fall. Some farmers find it a good practice to rib up the land in the late fall instead of giving it a second ploughing. When ribbing is practised the first ploughing is usually 6 to 7 inches deep. If manure is available it should be applied and ploughed under with the second ploughing, or, if ribbing is to be practised, the manure, if available, may be turned under with the first ploughing. If it is not possible to manure in the fall it could be applied in the winter or spring, but at these seasons very strawy manure should be avoided if possible,

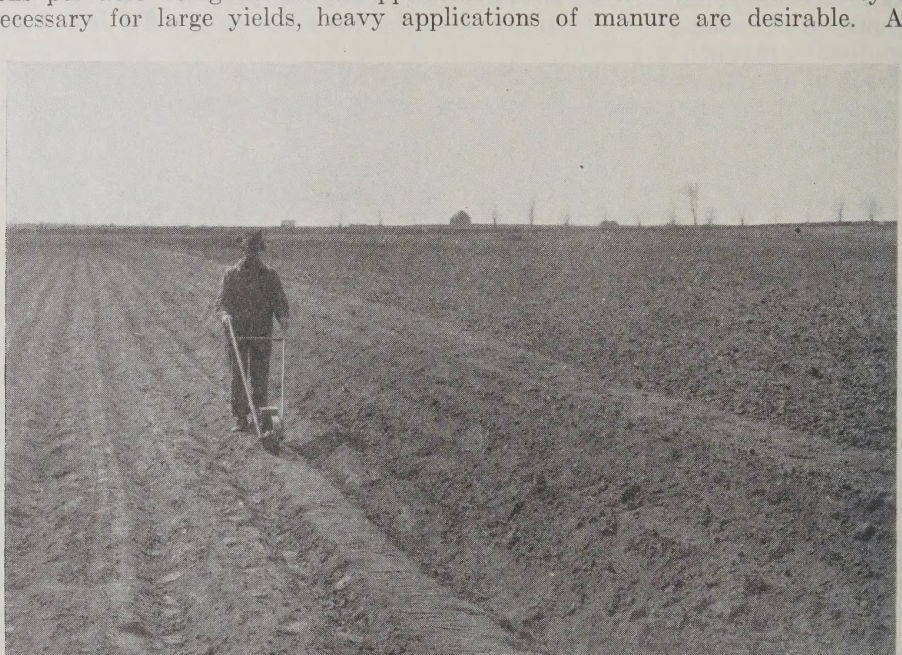
as it is difficult to disk it into the soil and it might, therefore, cause trouble in sowing. In the spring the land is well cultivated or disked, drag harrowed, rolled and ridged up, if the seed is to be sown on ridges.

Where roots are to follow stubble crops the land should be fall ploughed, but as stubble land is much easier to work into a seed-bed than sod land, there is not the necessity of ribbing, or of the second fall ploughing, as is the case where roots are to follow sod.

When it is impossible to fall-plough the land, early spring ploughing and very thorough working must be done.

MANURE AND COMMERCIAL FERTILIZERS

Manure is the most generally used fertilizer for root crops, from 12 to 20 tons per acre being the usual application. As an abundance of fertility is necessary for large yields, heavy applications of manure are desirable. An



The hand-seeder is particularly useful for sowing mangel and carrot seed.

experiment has been conducted for a long period of years at the Central Experimental Farm at Ottawa in which the yields of mangels from various manurial treatments have been compared. The mangels followed timothy sod in each case. The treatments given to the different areas of land were,—no manure, manure only, commercial fertilizers only, and manure supplemented by commercial fertilizers. The following table gives the average results from this experiment.

	Average yield 15 years
No manure	10·54 tons per acre
Manure only	21·63 " "
Commercial fertilizers only	19·87 " "
Manure and commercial fertilizers	21·66 " "

The area which received manure only was given a dressing of 15 tons per acre in the fall before ploughing for the mangel crop. The area receiving commercial fertilizers only was dressed with a mixture of 100 pounds of nitrate of soda, 300 pounds of superphosphate and 75 pounds of muriate of potash per acre just before the land was ridged up for sowing the mangel seed. On the fourth area 7½ tons of manure were applied in the previous fall, and one-half the quantity of the fertilizer dressing used on the area which was given only commercial fertilizers was applied before ridging up for sowing.

The manure and commercial fertilizer dressings used in this experiment are very satisfactory for the mangel crop and similar applications could be used for other root crops as well. If a manufacturer's mixed fertilizer were to be used it would require 400 pounds of a 4-12-9 fertilizer per acre to be equivalent to the dressing given, in the above experiment, to the area receiving commercial fertilizers only.

SOWING

There appears to be little difference in the average yields from roots sown on ridges and on the flat. The young plants, however, are more easily thinned when the seed is sown on ridges and, as it is more desirable to work the soil slightly away, rather than towards the young roots, this can be more easily accomplished by sowing on ridges. On the other hand, on very light soils or where the soil tends to dry out seriously during the growing season, sowing on the flat is recommended. If ridges are used they should be rolled before sowing and if the soil is dry it will be found good practice to roll lengthwise also after sowing. Mangel and carrot seed should be put in as soon as possible after the spring cereal crops have been sown. In the vicinity of Ottawa early May sowing is desirable. The results of many experiments show the necessity of early sowing if maximum yields are to be obtained. Swedes may be sown two to three weeks later than mangels but very late June sowing will result in reduced yields. From 6 to 8 pounds of mangel seed, 3 to 4 pounds of swede seed and 3 to 4 pounds of carrot seed should be sown per acre in rows 26 to 32 inches apart. The rougher and coarser the land the more seed should be sown, and the drier the land the more seed is required. Only fresh seed which is high in percentage germination should be used. Hand seeders are more satisfactory for sowing mangel and carrot seed than horse seeders. Swedes may also be sown with the hand seeder but the one-horse two-row turnip-seeder gives very good results and is much quicker.

Where no seeder is available, a shallow drill 1 to 1½ inches deep traced along the smooth surface of the top of the ridge with a dull pointed stick or the corner of a hoe will serve to receive the seed which is dropped by hand. The seed sown in this manner may be covered with a hand rake using the back thereof to draw the soil over the seed and to pack it down firmly.

The seed is usually sown one-half to one inch deep. It should be well covered and in contact with moist soil. The deeper seeding should be practised on light soils and the shallower on soils of a heavier type. It is better to be liberal with seed and not risk getting a poor stand. The cost of seed is small when compared with other items of expense in raising roots and therefore it pays to sow enough seed to ensure a good stand.

CULTIVATION AND THINNING

Early cultivation of the young plants is very desirable. Just as soon as the plants appear through the surface and the row can be followed, cultivation should begin with the hand wheel-hoe and horse cultivator. The wheel-hoe is particularly useful to stir the soil near the rows. It may be arranged so that

it will work the soil within half an inch of the plants, thereby destroying many small weeds, loosening the surface soil that has been packed by the roller, breaking up any crust formed by frequent showers and allowing the air to enter and warm the soil to hasten the growth of the young plants. The single-horse cultivator or scuffler should follow the wheel-hoe to kill weeds between the rows. When a wheel-hoe is not available the horse cultivator may, when driven with care, be made to cut close to the rows.

It is suggested by L. C. Raymond of Macdonald College that when roots are grown on the flat a tilting harrow or a weeder mounted on wheels may be used about three weeks after planting when the plants are ready to thin, to give the field a stroke crosswise of the rows. This, he maintains, will destroy many weeds, stir the soil and remove many superfluous plants.

The hand wheel-hoe is very useful in destroying weed seedlings close to the rows of young root plants.

Thinning should be done as soon as possible after the first pair of true leaves develop between the cotyledons or seed-leaves. The seed-leaves, in the case of the turnip, are the first pair of green kidney-shaped shoots or leaves to appear above the ground. In the case of the mangel, the seed-leaves are strap-shaped. Early thinning like early seeding gives highest yields. Mangels should be thinned 9 to 10 inches, swedes 10 to 12 inches and carrots 2 to 3 inches apart in the row. In thinning mangels and swedes one plant only should be left in each place. If two are left together only small and inferior roots will develop.

While the ordinary garden or weeding hoe is generally used in thinning mangels and turnips, some growers prefer to cut their hoe to a length of 4 to 6 inches, square the corners, sharpen three edges and straighten the neck a little so that the hoe may be used to push or pull out the undesirable plants.

For thinning carrots a special carrot-hoe is desirable. The blade should be 2½ inches wide with square corners. Hoes should always be kept sharp by using a file.

The strongest-growing and most vigorous and healthy-looking plant should be left wherever possible. If a miss or blank occurs of 18 inches or more, it is often well to leave two roots close together at either end in order to make as much use of the space as possible. Transplanting is sometimes practised but is not always successful. With a little practice the man who is willing to pay attention to his work will seldom find it necessary when thinning roots to do any hand work, unless the field is very dirty. A clean, firm cross-stroke between small clumps where a root is to be left, then a careful, rapid manoeuvering of the hoe to clear away the weeds and the other small mangels or turnips surrounding, or adjacent to, the favoured one, will be found a practicable and, after a little experience, even a rapid and easy operation. The man should stand sidewise between the rows, facing the row on which he is working. When so placed, he can work to better advantage, pushing and pulling from the favoured root with the sharpened ends of the hoe, and cutting between with the usual edge.

It is a good plan to go over the ground a second time two or three weeks after thinning in order to remove any surplus plants that had not been taken out at the first thinning.

The roots should be kept free of weeds all summer by frequent cultivations which should be continued until the leaves are fully developed and so shade the soil that weed growth is smothered. Two hoeings may be necessary to remove weeds during the growing season, the first being done when thinning.

HARVESTING

The harvesting of roots is always delayed until cool weather prevails. They are usually the last crop to be brought into storage. Swedes in particular make their best growth during the cool weather in the fall but other roots also continue to grow until fairly late in the season. Several degrees of frost do not materially injure the keeping qualities of swedes, but mangels and carrots should be harvested before any heavy frosts occur. Mangels and carrots which are still standing in the rows untopped should not be harmed by 4 to 5 degrees of frost, but lower temperatures are likely to cause injury, and even 5 degrees of frost might injure pulled roots lying uncovered on the ground. Swedes will stand several degrees more frost than mangels and carrots. Care must be exercised, however, to prevent the exposure of all kinds of roots to heavy frosts as they will, if badly frozen, become a complete loss when placed in storage. The average date of harvesting mangels at the Central Experimental Farm at Ottawa is October 15 and the average harvest date of swedes is October 20. No attempt should be made to bring in roots which have been frozen, until they have thawed out.

Mangels are usually pulled by hand and the tops twisted off. Cutting the tops off with a knife, unless very carefully done, will break the skin, and rotting of the mangels in storage is very liable to result. All the green leaves as well as any that have turned brown should be removed from the roots. A man may advantageously pull two rows at a time, throwing the roots in a row either to the right or left of him, as the case may be, but throwing them so that on his return trip the roots from the next two rows may be thrown with those from the first two, so that what grew in four rows standing will lie together in one row of pulled roots. This arrangement will leave room for a cart or wagon to pass along and be loaded from both sides.

Swedes may be harvested in a manner similar to mangels but as they are not as susceptible to injury from rough handling as mangels, the usual method of harvesting them is to cut off the tops with a sharp hoe and drag them out of the

ground with a drag-harrow by going across the rows. In the case of some varieties it may be necessary to use the plough to remove them. Where a potato digger is available it may be used to advantage, instead of the drag-harrow or plough, to take swedes out of the ground after they have been topped.

In removing carrots it is frequently necessary to run a plough parallel with the row leaving an inch or two of earth along beside the roots. The roots may then be pulled sideways, the tops twisted by hand or cut off with a knife and the carrots loaded into a cart or wagon.

The hauling in of roots should, if possible, be done on dry days, so as to enable the loaders to knock the roots free of soil. Throwing the roots into a wagon and then throwing them out again at the root house on a slide with a slatted bottom will usually ensure their going into storage fairly clean, a condition very necessary to their keeping well.

Unloading in this manner will ensure the roots going into the cellar free from earth.

STORAGE

The best place of storage is a root-cellar near where they are to be used for feeding. Such a cellar may be part of a barn or basement or may be built conveniently near the stable. The root-house or cellar should be well drained and well ventilated. A sandy soil and high ground provide ideal conditions, otherwise very careful drainage of the foundation will be necessary. The isolated cellar should be in a sheltered position with a south entrance if possible. Roots

should not be stored in the stable all winter as the temperature is likely to be too high and the roots, particularly swedes, may taint the air. Farmers sometimes find it necessary, however, because of absence of other space to store the roots in the stable for one and one-half to two months before opening the silo for winter feeding. In this case only sufficient roots are grown to feed the stock until the transition period, between outside and inside feeding, is passed. A well-drained earth floor for the cellar or root-house is much to be preferred to a cement bottom or wooden floor. To keep out the frost the root-cellar should be at least two-thirds below the surface of the earth and even then it may be necessary about the middle of December to bank up outside, with manure, the top of the cellar which is not under the earth. Light in the cellar is not necessary. Local conditions will materially influence the method of construction and the material used. Stone and cement walls will prove very satisfactory. Care should be taken to see that the roots may be easily put in and easily taken out. Ventilation intakes and outlets should be arranged in such a way that they can be closed during periods of severe frost. During the fall the doors and windows, in addition to the regular ventilators, should be kept open day and night, and especially at night, until there is danger of frost. If the roots are deprived of a circulation of air at any time during their storage period they will mould and spoil. The circulation of air in the cellar may be assisted by using slatted ventilators or shafts placed vertically reaching from the floor to the ceiling at various places in the cellar or house, 10 to 12 feet apart each way, around which the roots are piled. In very severe weather some isolated cellars away from buildings may require that heat be provided in some manner. A supply of heat, say by means of a small stove, would cause in the cellar a most desirable circulation of air.

When a cellar or root-house is not available, roots may be stored outside in a pit. Here again drainage and ventilation are essential to successful storage. A side hill is best for the location of the pit to insure no water lying within it. An excavation is made 1 foot to 18 inches in depth and not more than 5 feet wide. The length should be determined by the amount of roots to be stored. It is rarely made longer than 40 feet. Upright wooden ventilators about 6 to 8 inches square and long enough to reach from the bottom of the pit to a foot above its final height are placed about 5 feet apart through the centre of the pit. The end ventilators should be placed not less than 4 feet from the ends of the pit. These ventilators should be solid on two sides with 4-inch openings about 1 foot apart on the other two sides. The roots are piled in pyramid form $2\frac{1}{2}$ to 3 feet above the level of the surrounding land. Two to three inches of straw are then placed over the pile of roots and left for 2 or 3 days so that the roots may sweat and dry out. After 3 days the depth of the straw should be increased to 1 foot which, when packed, will be about 6 inches. On top of the straw is placed about 6 inches of earth, leaving a strip about 1 foot wide the length of the pit uncovered with earth, for further evaporation of moisture from the roots. Over this uncovered straw are placed two boards to form an inverted "V" or trough to prevent rain from entering the pit. In two weeks or so when the first cold weather sets in the boards are removed and a layer of earth 6 inches in depth takes their place. When the layer of earth is frozen hard enough to bear the weight of a man another layer of straw similar to the first is placed over the entire pit, except the ventilators, and another 6 inches of earth is put on top of the straw. In extremely cold and in extremely mild weather the ventilator openings should be stopped with pieces of old bags or by other means.

If care is exercised in placing the roots in storage and if precautions are taken to see that the cellar, house or pit is properly constructed and cared for during the storage period, the roots should come through the winter in good shape.

50249—3

COST OF PRODUCING AND VALUE PER ACRE OF ROOTS AND CORN SILAGE

The cost of producing roots as well as other common farm crops has been studied by the Dominion Experimental Farms throughout Canada for many years. Accurate records have been kept of the amounts of manual and horse labour used per acre from year to year. The cost of labour and the cost of all other items which enter into the growing of crops, such as rent and taxes, manure, seed, machinery and twine have been carefully tabulated. Most of these cost data which have been collected in the past have been published in the annual reports of the Division of Field Husbandry and of the Branch Experimental Farms.

Inasmuch as roots and corn for silage are the most important succulent forage crops now in use in Eastern Canada it may be of interest to compare them in respect to their costs of production and their values per acre. The labour requirements for these crops given in one of the following tables are the average figures collected for the past four years on farms in Eastern Canada. The cost figures are based on 1927 prices.

LABOUR REQUIREMENTS PER ACRE, BY OPERATIONS, IN PRODUCING ROOTS AND CORN SILAGE ON THE EXPERIMENTAL FARMS AND STATIONS OF EASTERN CANADA.

Kind of Operations	Roots		Corn silage	
	Manual	Horse	Manual	Horse
Ploughing	8·2	18·3	8·5	18·5
Disking	5·0	14·5	5·7	14·4
Harrowing	2·9	6·5	3·1	5·3
Rolling	0·8	1·6	0·5	1·0
Ridging for roots	3·5	7·0	.....	.....
Seeding	*1·6	1·6	2·1	4·2
Hoeing and thinning	52·3	.....	14·0	.....
Cultivating	8·7	14·1	4·5	6·8
Topping, pulling and hauling roots	59·0	24·0	.....	.....
Cutting corn	.....	.....	3·7	5·6
Hauling and filling silo	.....	.....	30·1	13·7
	142·0	87·6	72·2	69·5

* If roots are sown with a hand seeder it requires about four hours of manual labour per acre.

LABOUR REQUIREMENTS AND COST OF PRODUCING ROOTS AND CORN SILAGE ON THE EXPERIMENTAL FARMS AND STATIONS OF EASTERN CANADA

—	Roots	Corn silage
Labour requirements—		
	hours	hours
Manual labour	142·0	72·2
Horse labour	87·6	69·5
Items of cost—	$ cts.	$ cts.
All items but labour (including rent and taxes, manure, seed, machinery and twine)	22 80	25 85
Labour (manual and horse)	40 00	22 83
Total cost per acre	62 80	48 68
	tons	tons
Yield per acre	19·5	14·1
	$ cts.	$ cts.
Cost per ton	3 22	3 45

It is difficult to arrive at an exact estimation of the value of corn silage and roots per ton. They are not sold on the market in large enough quantities to fix any market valuation and hence must have an arbitrary value given to them. There is more than one method of calculating their value. The method used by the Field Husbandry Division at the Experimental Farm at Ottawa is to base the value of silage and roots on their dry matter contents. Feeding trials given on page 18 of this bulletin demonstrate that the dry matter of mangels has 15 per cent more feeding value than the dry matter of corn silage. As the average dry-matter content of roots is usually from 10 to 12 per cent while that of corn silage is from 20 to 25 per cent, the higher value given to the dry matter of roots does not offset the much larger yield of dry matter secured per acre from corn silage in most parts of Canada.

In order to arrive at the value in dollars and cents of a ton of roots and of corn silage it is necessary to use as a standard some crop which because it is sold on the market has a definite price. The crop which is frequently used is hay. Feeding experiments have shown that in general 100 pounds of hay is equal in value to 300 pounds of corn silage which has a dry-matter content of 25 per cent. If, therefore, hay were worth $12 per ton, corn silage would be worth $4 per ton. If roots average 11 per cent dry matter and this dry matter is 15 per cent more valuable than the dry matter of corn silage the value of roots per ton would be $2.02.

These calculations indicate that where corn and roots grow equally well, corn is almost always the more profitable crop. Where only a small amount of succulent stock feed is required, however, or on small farms where manual labour is not such an important factor, farmers may find roots more economical than corn because of the expenditure required to purchase corn harvesting equipment and to provide for the corn, suitable winter storage. In the colder regions of Eastern Canada where, because of unfavourable climatic conditions, corn gives very low total and dry-matter yields, roots are likely, here also, to be the more economical crop to grow.

50249—3½

FEEDING FIELD ROOTS TO LIVE STOCK

By G. B. ROTHWELL, B.S.A., DOMINION ANIMAL HUSBANDMAN

ROOTS FOR HORSES

There is no question but that roots form one of the valuable feeds for horses, and one the value of which, unfortunately, is all too little appreciated. Possibly turnips and carrots are the most acceptable of the root crops as feeds for horses. Mangels are frequently made use of but lack comparatively in palatability.

Roots are valuable for keeping the brood mares in good breeding condition.

The chief value of roots in the ration for horses may be summed up as follows:—

1. Increase palatability.
2. Form a succulent addition highly desirable, forming as it does a food in the natural or unchanged form.
3. Assists in or increases the digestibility of coarse fodders.
4. Benefits the teeth and gums.
5. Are slightly laxative.
6. Cheapens the ration.
7. Form a splendid tonic or conditioner.

Roots may be utilized with excellent results during certain ages and temporary periods in the life of the horse.

For the idle horse or for horses on what might be termed a maintenance ration, they constitute an economical and healthful item of diet. It is recommended that for every 100 pounds of the horse's weight there be fed 1 pound of mixed hay, 1 pound of clean oat straw, and 1 pound of turnips. The Experimental Station at Cap Rouge reports that a ration of 1 pound of mixed hay, 1 pound of oat straw, and 1 pound of carrots or swede turnips per 100 pounds

live weight daily when fed to six idle geldings and mares ranging from 6 to 19 years of age during a period of 150 days from November 1 to March 31, resulted in every one being in good shape at the end of the test, the average gain in weight being 28 pounds. During the first two weeks of the test the feed was gradually reduced to the quantities named and during the last two weeks again increased to normal.

On the Dominion Experimental Farms generally, turnips and carrots are commonly used in the above connection.

For in-foal mares during the winter months there is no better adjunct to the ration than roots. The succulent, tonic, and laxative properties are then of peculiar value as is the ease of digestibility.

For foals and yearlings, roots may be used with excellent results; carrots, turnips or mangels fed 2 to 4 pounds daily.

For the horse at moderate farm work during the winter, roots are valuable, even if mainly from the standpoint of palatability and health-giving qualities rather than actual energy producing power. A horse at ordinary winter work will relish a feed of carrots, turnips (or mangels if the two former are not available) just as much as his owner relishes a crisp Northern Spy apple, and with just as good results. Many feeders make a practice of throwing two or three turnips into the manger when the horse comes in at night and of giving the regular evening grain, say, after supper.

Roots are rarely sliced or pulped for horses. In fact, as already pointed out, one virtue in root feeding is the beneficial effect on the teeth and gums due to the necessary biting into the whole root.

ROOTS FOR DAIRY CATTLE

When roots are fed to dairy cattle, it is usually mangels or half sugar mangels that are used. This preference is based quite largely on the fact that they have not the objectionable odour and flavour of turnips which are readily absorbed by the milk, causing tainting, unless special precautions are taken. In addition to this, however, the mangels seem to be somewhat more economical to grow, more palatable and of slightly higher feeding value for milk production. As to the relative value of classes and varieties of roots, an experiment was conducted at the Central Experimental Farm, of which the following table is a summary, which will throw some light on this phase of the subject.

VALUE OF VARIOUS ROOT CROPS—SUMMARY OF EXPERIMENTS

Table	I		II		III		IV		V		VI	
Period	Canadian Gem Turnips		Good Luck Turnips		Champion Yellow Carrots		Detroit Red Beets		Yellow Intermediate Mangels		Half-Sugar White Mangels	
Ration	Mangels	Turnips	Mangels	Turnips	Mangels	Carrots	Mangels	Beets	Mangels	Mangels	Mangels	Mangels
Average milk per cow per day. lb.	54·85	52·97	52·39	52·12	46·33	46·57	50·50	50·64	43·92	43·37	42·05	40·27
Average fat per cow per day... "	1·86	1·78	1·84	1·78	1·69	1·64	1·83	1·88	1·56	1·62	1·51	1·49
Average per cent fat..... %	3·39	3·35	3·50	3·41	3·55	3·52	3·64	3·71	3·56	3·74	3·57	3·66
Feed cost to produce 100 lb. milk ct.	54·42	56·25	57·96	58·70	65·48	65·01	59·98	59·79	72·52	73·44	75·82	76·63
Feed cost to produce 100 lb. fat $	16·04	16·77	16·53	17·22	18·43	18·48	16·48	16·09	20·34	19·59	21·02	20·71
Dry matter content of the roots %	10·21	10·39	10·21	11·35	10·21	9·87	10·21	11·64	10·21	10·50	10·21	10·37

The first column of the table under each period gives the results when the cows were fed on the basic ration which contained Mammoth Long Red mangels, while the second column gives the results when the cows were fed a substitute for the Mammoth Long Red mangels, the substitute being named just above. The most apparent feature of the results of this experiment as summarized in the preceding table is that no one class or variety of roots stands out particularly prominently in its ability to produce milk or butter-fat. However, it will be noticed on closer examination that the mangels lead in the amount of milk and butter-fat produced in the majority of cases, one exception being when the Detroit Red beets were fed. During this period a slight increase in the percentage fat is shown when beets were fed, while previously the mangels had shown the highest percentage fat. The Yellow Intermediate and Half Sugar White mangels gave slightly better results than the Mammoth Long Red variety. This is to be expected, as they contain slightly more dry matter, while the extra good

Roots may be used to advantage for calves from four to ten months of age.

showing made by Detroit Red beets may be due to the fact that they had the highest dry-matter content of any of the classes or varieties experimented with.

Fairly conclusive experiments have been conducted in testing roots (mangels) against corn silage at the Central Experimental Farm, Ottawa. In these experiments, roots have replaced corn on a dry-matter basis. An average of the results shows that when mangels replaced corn silage entirely, the mangels produced 5.65 per cent more milk but no increase or decrease in the amount of fat. When a ration of half corn silage and half mangels was compared to one of corn silage only, the mangels ration produced 0.15 per cent more milk and 8.15 per cent more fat. In all cases, however, increased production due to feeding mangels was not sufficient to overcome the greater cost of the mangel ration, so that under conditions at the Central Experimental Farm, Ottawa, corn silage proved the most economical feed. The mangels were less economical on account of the low percentage of dry matter that they contain and consequent greater total weight of mangels required to furnish sufficient dry matter in the ration.

Comparative values of corn silage and roots, both on a ton for ton basis and on a dry-matter basis, were arrived at in summarizing the above experiments and reported on in the 1925 report of the Animal Husbandry Division as follows:—

Three-Year Average of Comparison of Corn Silage and Roots

In all cases in this comparison, corn silage is taken as the standard. The corn silage is valued at cost, and the comparative value of roots is estimated on this basis. This procedure gives the following relative values for a comparison of straight silage and root rations.

CORN SILAGE vs. ROOTS

—	Cost of silage per ton	Cost of roots per ton	Value of roots as compared to corn at cost price per ton
	$ cts.	$ cts.	$ cts.
1923 results	2 95	2 50	1 47
1925 results	3 10	4 10	2 20
Average	3 02	3 30	1 83

In other words, roots are only 60 per cent as valuable as corn silage for milk production.

When roots are used in conjunction with silage, *i.e.* replacing a part only of the silage in the ration, they attain a higher value, as the following table will show:—

CORN SILAGE vs. ROOTS AND CORN SILAGE

—	Cost of silage per ton	Cost of roots per ton	Value of roots as compared to corn at cost price per ton
	$ cts.	$ cts.	$ cts.
1923 results	2 95	2 50	2 24
1924 results	3 15	3 35	1 96
1925 results	3 10	4 10	2 51
Average	3 07	3 32	2 24

In other words, when fed in limited quantities as a supplement to corn silage, roots are 73 per cent as valuable as corn silage for milk production, a gain of 13 per cent in value compared to when they are fed alone.

A comparison of these two crops on a dry-matter basis is interesting. Taking the 1923 and 1925 results, when straight comparisons of corn silage were made, the following are the results:—

DRY MATTER OF ROOTS AND SILAGE

—		1923		1925	
		Roots	Silage	Roots	Silage
Percentage dry matter	%	10·9	23·4	11·7	19·7
Amount dry matter per ton	lb.	218·0	468·0	234·0	394·0
Relative value dry matter per ton	$	1·47	2·95	2·20	3·10

Calculated on this basis, averaging the two years' work, the dry matter in corn silage is worth 70 cents per 100 pounds, while the dry matter in roots is worth 81 cents per 100 pounds. That is, the dry matter in roots is worth 15 per cent more than the dry matter in corn silage.

Taking the 1923, 1924 and 1925 results, when a mixture of corn silage and roots was compared to straight corn silage, we find the following results to obtain:—

DRY MATTER—IN CORN SILAGE AND ROOT MIXTURE AND CORN SILAGE ALONE

		1923		1924		1925	
		Roots	Silage	Roots	Silage	Roots	Silage
Percentage dry matter.....	%	10·9	23·4	10·9	23·75	11·7	19·7
Amount dry matter per ton.....	lb.	218·0	468·0	218·0	475·0	234·0	394·0
Relative value dry matter per ton.	$	2·24	2·95	1·96	3·15	2·51	3·10

Calculated on this basis, averaging the results of the three years' work, the dry matter in corn silage is worth 68.8 cents per 100 pounds, while the dry matter in roots is worth 85.2 cents per 100 pounds. That is, when fed as a supplement to corn silage, the dry matter in roots is worth 23.8 per cent more than the dry matter in corn silage. In other words, the dry matter in roots is 8.8 per cent more valuable when fed in limited quantities as a supplement to corn silage than when the roots are fed as a straight ration of themselves.

The preceding figures go to show that where corn silage is difficult to grow or the crop is at all uncertain and yet a crop of mangels can be successfully grown, the latter crop will be a most economical one. It also goes to show that even where corn silage is grown, a ration of corn silage can be materially improved by replacing a portion of it by an equal amount of mangels, provided the replacement is made on a dry-matter basis.

ROOTS FOR BEEF CATTLE

When roots are fed to beef cattle, turnips are invariably used, as it is fairly generally recognized that turnips are more suitable for fattening purposes than mangels, the latter being better suited for milk production. Practically all of the experiments in the feeding of roots to beef cattle have been conducted on the eastern Experimental Farms and Stations, namely, Nappan, N.S.; Kentville, N.S.; and Fredericton, N.B.

At Nappan, N.S., two years' work (three separate tests) has been carried on testing roots (turnips) against corn silage, replacing one-half the corn silage by an equal weight of roots and all of the corn silage by an equal weight of roots. When all of the corn silage was replaced by roots, greater gains were made by the steers than when silage was fed. Similar results were obtained when only half the corn silage was replaced by roots. As regards the average cost of gains, they were 10.74 cents per pound for roots alone, 11.32 cents per pound for roots and silage, and 11.828 cents per pound for silage alone, so that the costs were consistent with the gains. Valuing hay at $7 per ton, silage at $3 per ton, and grain at $40 per ton, roots were found to have a corresponding value of $4 per ton when used to replace corn silage either entirely or in part. It is to be noted, however, that at Nappan, N.S., the conditions are more favourable to a root crop than to a corn crop, the corn crop being an almost complete failure in 1918.

At Kentville, N.S., there are the results of three years' work comparing roots (turnips) with corn silage. Corn silage was replaced entirely by turnips, 1½ pounds of the latter being fed for every pound of the corn silage. The average of the three years' work shows that when fed on this basis, the gains are practically equal. Therefore 1 pound of silage proved equal to 1.31 pounds

of roots. The cost per pound gain was slightly less with roots (12 cents per pound) than with silage (12.32 cents per pound), the roots being charged at $3 per ton and the silage at $4 per ton. If the silage were valued at $3 per ton as in the case of the Nappan comparison, roots would have shown a value of $2.30 per ton.

At Fredericton, N.B., one experiment has been conducted comparing a ration for steers, composed of hay, grain, and roots (turnips), with one composed of hay and roots only. The gains and profits naturally were higher where grain was fed, but a substantial profit over feed cost was realized where roots and hay only were fed. Valuing hay at $7 per ton and grain at $40 per ton, roots attained a value of $2.60 per ton in this experiment.

It will be seen, therefore, that roots have a high value when used for the feeding of beef cattle. They are particularly valuable when no other succulent feed is available. Pulped and mixed with cut or chaffed straw or poor-quality hay, they improve the palatability and feeding quality of these coarse roughages very much.

Roots are valuable for feeding ewes nursing lambs before grass is available.

ROOTS FOR SHEEP

No class of sheep derives more benefit from roots, particularly swede turnips, than the breeding ewes. A moderate ration of roots improves the health, vigour, and milking ability of the flock and the lambs benefit accordingly. A heavy ration of grain and hay unsupplemented with some succulence such as roots, is more likely to cause digestive troubles among the ewes and also a decreased number of healthy lambs.

While there is little danger of overfeeding roots to sheep, the quantity which can be profitably fed is limited. When feeding 1½ to 2 pounds of hay approximately 1½ to 2½ pounds of roots may be fed per head per day. Occasionally, as much as 4 pounds may be profitably fed, but when feeding roots the point must not be lost sigh of that they are mainly useful as a source of succulence, and a relatively small quantity is effective for this purpose.

Mangels are not as safe a feed as turnips, particularly for rams. Carrots can be used successfully to take the place of swede turnips, but are a less reliable crop in that they are more difficult to grow successfully.

ADDING TURNIPS TO A HAY AND MEAL RATION FOR FATTENING LAMBS

For fattening lambs experimental tests throughout the Experimental Farm System indicate that when added to a ration of grain, hay and some straw, the roots increased the rate of gains but also resulted in increased costs when compared on the basis of cost of feed per pound of gain with a non-root ration. A representative test is given here.

Four lots of lambs were fed in 1912-13 and again in 1913-14 at Nappan. The rations included clover hay, roots, and meal; clover hay and meal; timothy hay, roots, and meal; and timothy hay and meal. Hay was fed at the rate of 1.5 pounds per lamb daily, roots 2.5 pounds at the start and this increased to 4 pounds, and grain at 0.75 pounds and increased to 1.75 pounds.

AVERAGE RESULTS FOR TWO YEARS' TESTS

—		Roots Clover	Clover	Roots Timothy	Timothy
Number of lambs in lots	No.	24	23	24	22
Average initial wt.	lb.	84·12	84·38	80·0	74·21
Average final wt.	"	107·87	104·78	103·08	93·55
Average gain per lamb in 97 days	"	23·75	20·6	23·08	19·34
Average daily gain per lamb	"	0·24	0·21	0·24	0·20
Meal eaten per pound gain	"	5·29	6·05	5·41	6·39
Hay eaten per pound gain	"	6·34	7·26	6·52	7·67
Roots eaten per pound gain	"	16·5	.....	16·9	.....
Feed cost per pound gain	cts.	14·11	12·9	14·45	14·06

The addition of turnips to the ration increased the rate of gains slightly, but proved more expensive to feed in the quantities named when added to a ration consisting of timothy and meal or clover and meal.

In this test 299 pounds of clover hay and 248 pounds of grain were equivalent to 4,704 pounds of roots. With the meal valued at $32 per ton and the hay at $10, the roots had a relative feeding value of $2.32 per ton in this ration. On the same basis of comparison, 314 pounds of timothy hay and 168 pounds of grain were equivalent to 4,704 pounds of roots, and at the prices already quoted for hay and meal, the roots here had a relative value of $1.81 per ton.

The values on roots may seem low, but it must be kept in mind that the valuation placed on the other feeds is not high and any increase in the values of these would give roots a correspondingly greater cash value in these rations.

ROOTS FOR SWINE

Mangels, sugar mangels, and sugar beets excel in providing succulence for all classes of swine, both young and mature breeding stock and growing pigs for winter feeding.

Turnips are also valuable but are not relished to quite the same extent as mangels. When cooked, however, their feeding value and palatability is enhanced.

For brood sows, mangels may be fed whole with quite satisfactory results but better results are obtained when they are pulped; and for other classes of swine they should always be pulped. Generally speaking, mangels, sugar mangels, and sugar beets should be fed raw, but when fed warm they are frequently taken somewhat more readily in very cold weather.

Brood sows can profitably utilize larger quantities of roots than feeders and up to 15 pounds daily may be fed in conjunction with a light meal ration, composed of equal parts of bran and shorts, or bran, shorts and oats. Feeding

at the rate of 2 pounds of roots to one of meal will usually be found satisfactory. This quantity of roots, however, should be gradually reduced a few weeks before farrowing.

For feeders or young breeding stock, about 6 to 10 pounds of roots is sufficient when fed at the rate of 1 or 2 pounds to 1 pound of meal.

Roots are also valuable during the fattening period but should not be used as liberally at that time and a usual practice at that time is not to feed in excess of 1 pound of roots to each pound of meal consumed.

Pulped mangels, half sugar mangels and sugar beets are excellent for young breeding stock and brood sows.

MANGELS VS. POTATOES FOR YOUNG FEEDER PIGS

A test conducted at Brandon in 1915 included four lots of pigs, one lot getting cooked potatoes, one raw potatoes, one cooked mangels, and one raw mangels, as supplements to a meal ration composed of 2 parts of barley, 1 part of shorts and approximately 14 per cent of tankage. During the greater part of the test meal was fed at 1½ pounds per pig daily and mangels or potatoes at 7 to 7½ pounds. Equal amounts of each feed were given each lot.

MANGELS vs. POTATOES FOR YOUNG FEEDER PIGS

—		Cooked Potatoes	Raw Potatoes	Cooked Mangels	Raw Mangels
Number of pigs	No.	4	4	4	4
Average initial weight	lb.	53·7	56·0	53·2	52·7
Average final weight	"	90·2	82·5	87·0	80·7
Average daily gain in 50 days	"	0·73	00·53	0·67	0·56
Meal eaten per lb. gain	"	3·16	4·35	3·42	4·12
Mangels eaten per lb. gain	"	.....	.....	11·00	13·25
Potatoes eaten per lb. gain	"	10·16	14·00	.....	.....
Feed cost per lb. gain	cts.	7·23	9·77	7·68	9·25

Cooked potatoes and meal stood first in this test followed by the cooked mangel and meal ration, while raw potatoes and meal had a slightly lower value than raw mangels, which ranked third. In this test 462 pounds of meal and

1,484 pounds of cooked potatoes were equal in feeding value to 636 pounds of meal and 2,043 pounds of raw potatoes, 503 pounds of meal and 1,604 pounds of cooked mangels or 601 pounds of meal and 1,933 pounds of raw mangels.

A further test at Brandon comparing cooked mangels and raw mangels was made the same year as the former test. Lots I and III received 1 pound of barley, $\frac{1}{2}$ pound of shorts and $7\frac{1}{2}$ pounds of mangels per day, while the check lot No. II received double the amount of meal but no mangels. Approximately $\frac{2}{5}$ pound of tankage was fed per pig per day.

COOKED vs. RAW MANGELS FOR YOUNG FEEDER PIGS

—		Cooked Mangels	Raw Mangels	Check Lot
Number of pigs in lots	No.	4	4	4
Average initial weight	lb.	46·2	48·7	47·5
Average final weight	"	95·7	105·5	102·2
Average gain per pig	"	49·5	56·7	54·7
Average daily gain in 56 days	"	0·88	1·01	0·98
Meal eaten per lb. gain	"	2·28	1·94	2·62
Mangels eaten per lb. gain	"	8·49	7·40	.....
Feed cost per lb. gain	cts.	5·25	4·14	5·67

The cooked mangels show up poorly in this test and this may, in part, be explained by the presence of one unthrifty pig. With the meal ration valued at $32 per ton the raw mangels had a feeding value of $6.93 per ton in this test or, considered from another angle, 805 pounds of meal was equal to 441 pounds of meal and 1,680 pounds of mangels. The cooked mangels had a value of $5.26 per ton or 505 pounds of meal and 1,825 pounds of cooked mangels were equal to 805 pounds of meal.

TURNIPS VS. MANGELS FOR FEEDER PIGS

At Ottawa in 1912, two tests were conducted in which pulped mangels were compared with pulped turnips both cooked and raw. The meal ration for all lots was composed of two parts of ground barley, two parts of shorts, and one part of ground oats.

TURNIPS VS. MANGELS FOR FEEDER PIGS

—		Milk	No. succulence	Cooked pulped turnips	Raw pulped turnips	Pulped mangels
Number of pigs in lot		20	20	20	20	20
Average initial weight	lb.	89·5	100·0	74·0	85·1	100·6
Average final weight	"	148·6	147·4	110·4	118·6	145·0
Average gain per pig	"	69·1	47·4	36·3	34·5	44·3
Average daily gain in 84 days	"	0·82	0·564	0·432	0·41	0·533
Total meal eaten by lot	"	3,214	4,060	2,729	2,608	3,573
Total roots or milk eaten by lot	"	3,214	.....	2,729	2,608	3,573
Meal eaten per pound gain	"	2·72	4·28	3·75	3·77	4·03
Roots or milk eaten per pound gain	"	2·72	.....	3·75	3·77	4·03
Cost of feed per pound gain	cts.	4·89	6·85	6·88	6·81	7·25

With meal valued at $32 per ton, the skim-milk had a relative value of 0.9 cents per pound; cooked turnips, $4.45 per ton; raw turnips, $3.83 per ton; and raw mangels, $1.28 per ton.

TURNIPS FOR FEEDER HOGS

At the Farm at Ottawa a test was conducted in which cooked turnips were fed as a supplement to the meal. The meal ration was fed as a water slop and comprised equal parts of ground barley and oats. The test was conducted in duplicate.

TURNIPS FOR FEEDER HOGS

—		Meal	Meal and turnips
Number of pigs in lot	No.	10	10
Average initial weight	lb.	125·0	127·2
Average final weight	"	187·8	192·6
Average gain per pig	"	62·8	65·4
Average daily gain in 63 days	"	0·99	1·03
Meal eaten by lot	"	2,623	2,537
Turnips eaten by lot	"	.....	2,537
Meal eaten per pound gain	"	4·18	3·88
Turnips eaten per pound gain	"	.....	3·88
Cost of feed per pound gain	cts.	6·66	6·98

The addition of cooked turnips increased the rate of gains in weight and reduced the meal consumed, but with meal valued at $32 per ton and turnips at $4 per ton the difference was not sufficient to overcome the increased cost of the ration.

With meal at the valuation given, 2,730 pounds of meal was equal to 2,537 pounds of meal and 2,537 pounds of cooked turnips and this gives the turnips a value in this ration of $2.43 per ton.

SUMMARY—VALUE OF ROOTS FOR FEEDER SWINE

Experiment	Meal ration fed	Succulence fed	Comparative Feeding Value	
			Meal	Succulence
1	Ground barley, 2 parts Shorts, 2 parts Ground oats, 1 part Tankage, 14 p.c.	Cooked potatoes.. Raw potatoes..... Cooked mangels.. Raw mangels.....	lb. 462 + lb. 1,484 " 636 + " 2,043 " 503 + " 1,604 " 601 + " 1,933	Equal in feeding value.
2	Ground barley, 2 parts Shorts, 1 part Tankage	Control lot..... Cooked mangels.. Raw mangels.....	" 805 + " ..... " 505 + " 1,825 " 441 + " 1,680	Equal in feeding value.
3	Ground barley, 2 parts Shorts, 2 parts Oats, 1 part	Control lot..... Milk..... Cooked turnips... Raw turnips..... Raw mangels.....	" 5,058 + " ..... " 3,214 + " 3,214 " 4,440 + " 4,440 " 4,517 + " 4,517 " 4,869 + " 4,869	Equal in feeding value.
4	Ground barley, 1 part Ground oats, 1 part	Control lot..... Cooked turnips...	" 2,730 + " ..... " 2,537 + " 2,537	Equal in feeding value.

PULPED MANGELS VS. BEET PULP FOR PREGNANT BROOD SOWS

This test was commenced at Ottawa in the winter of 1921-22. These feeds were supplied as succulence in the ration of brood sows throughout the gestation period. The meal ration consisted of shorts, 1 part (by weight); bran, one part; screenings, 2 parts; tankage, 5 per cent.

—		Beet pulp, meal and water	Pulped roots, meal and water
Number of sows in experiment	No.	4	5
Number of days in experiment (average)	days	114	114
Quantity of meal eaten by group for period	lb.	3,192	2,850
Quantity of meal eaten per animal	"	798	570
Quantity of roots or beet pulp eaten by group	"	456	2,850
Quantity of roots or beet pulp eaten per animal	"	114	570
Condition of individuals		good	good
Total cost of feed	$	45·47	43·48
Cost of feed per head	$	11·37	8·69

Results of Farrowing		Lot I — Beet pulp, meal and water	Lot II — Pulped mangels, meal and water
Number of sows in experiment	No.	4	5
Total number of pigs farrowed	"	36	60
Average number of pigs farrowed per litter	"	9	12
Total number of good pigs	"	29	49
Average number of good pigs per litter	"	7·25	9·8
Total number of small and weak pigs	"	4	10
Average number of small and weak pigs	"	1	2
Total number of dead pigs	"	3	1
Average number of dead pigs	"	0·75	0·2
Total weight of litters at birth	lb.	102	165
Average weight of litters at birth	"	25·5	33
Average weight of pigs at birth	"	2·83	2·91
Average feed cost per pig at farrowing	cts.	166·8	90

This test was repeated in 1922-23, five sows being available for comparison. One lot of sows was fed 5 pounds of pulped mangels and 5 pounds of a meal ration comprising oats, 1 part; bran, 2 parts; shorts, 2 parts; tankage, 5 per cent; and bone meal, 2 per cent, and the other lot was fed 7 pounds of meal and 1 pound of beet pulp per sow per day.

RESULTS AT FARROWING

—		Beet pulp	Pulped mangels
Number of sows in experiment	No.	5	5
Total number of pigs farrowed	"	53	63
Average number of pigs per litter	"	10·6	12·6
Total number of good pigs	"	48	52
Total number of small and weak pigs	"	4	9
Total number of pigs born dead	"	1	2
Total weight of pigs	lb.	123	159
Average weight per pig	"	2·32	2·52
Average feed cost per pig at farrowing	$	1·413	0·867

The results from both these tests are in accord in that the pulped mangels in the ration appeared to be superior to beet pulp for pregnant brood sows. The sows getting mangels farrowed 12.3 pigs on the average, while the beet pulp sows averaged 9.9 pigs per litter. In weight of pigs per litter, the mangel ration was again superior with an average per pig of 2.63 pounds as compared to 2.53 pounds for the pigs from the sows on beet pulp.

While the factor of heredity will undoubtedly influence the size of the litters, the fact that the results for the two years from different sows are similar would indicate that pulped mangels are superior as a source of succulence to beet pulp for pregnant brood sows.

In the comparison of feed costs the results are even more pronounced, the pigs from the beet-pulp lot showing an average feed cost per pig of $1.54, while the mangel lot showed an average feed cost per pig at birth of 88.3 cents of approximately 65 cents less per pig. These values are calculated with the meal rations valued at $34 per ton, the beet pulp $25.50 per ton and the mangels at $4 per ton.

MANGELS AS POULTRY FEED

BY F. C. ELFORD, DOMINION POULTRY HUSBANDMAN

The chief value of roots as a poultry feed lies in the fact that they can be stored during the winter months, and fed over the period during which fresh green feeds are not available. They should not be considered in any way as a complete substitute for fresh green feeds, chiefly because they are quite deficient in vitamine content. The anti-neuritic and anti-scorbutic vitamines are present in only the slightest traces while the anti-rachitic vitamine is entirely lacking. In comparison fresh clover, one of the most commonly used green feeds, contains all three in abundance. The chief function of mangels and roots in general is the supplying of succulence to the ration. It has been found that by using mangels and supplementing with a regular dosage of Epsom salts, laying birds will come through the winter in fairly good shape.

In an experiment carried on at the Central Experimental Farm in which mangels, sprouted oats, clover leaves, cabbages, and Epsom salts were contrasted both as to economy of production and to hatching results obtained, mangels gave the greatest production and profit, but fell down somewhat in the hatching results. Over a two-year period, however, both sprouted oats and clover leaves excelled mangels in every respect.

In another experiment in which feeds of a like nature were tested one against the other mangels gave the highest feed cost per dozen eggs, lowest production, least profit over cost of feed, and lowest percentage of fertile eggs hatched. These results would tend to bear out past experimental work and would suggest that mangels be used as a supplement to the ration when fresh green feed is not available.

CHEMICAL STUDIES OF FARM ROOTS

BY FRANK T. SHUTT, D.Sc., F.I.C., DOMINION CHEMIST

Roots may be said to have a dual value, nutritive and medicinal, in the ration of farm stock; they are extremely palatable and have marked appetizing qualities. Furthermore, they are highly digestible. In addition, they enable dry roughages (hay and straw) of an inferior quality to be utilized more completely and profitably.

Though not furnishing in notable quantities either protein or fat, roots possess an appreciable feeding value. This depends on their comparatively large percentages of sugar and other readily assimilable carbohydrates—the chief function of which is to supply heat and energy to the system as well as to serve as an important foundation material for conversion into fat.

Apart from their intrinsic value from the feeding standpoint there are several qualities or properties possessed by roots which must not be overlooked. Of these, succulence probably stands first for the reason that it enhances palatability and palatability stimulates digestion. Associated as it is here with ready and practically complete digestibility of the nutrients, it is undoubtedly a factor of no small importance in the keeping up of the milk flow. Further, it would appear that roots may materially aid in the digestion of the rest of the ration and prove useful in the proper distension of the digestive apparatus.

Stock feeders of experience have recognized roots as performing a useful function in maintaining the health and thrift of the animal. This is largely owing to their richness in saline matter, which consists chiefly in potash compounds. These are mildly laxative and possibly possess other beneficial properties.

MANGELS

Farm roots and corn may be said to serve the same purpose in stock feeding—the furnishing of a palatable, wholesome, succulent forage for winter use. The best returns from corn, as is well known, are obtained in districts characterized by hot summers, whereas farm roots (mangels, etc.,) thrive in more temperate areas with a longer and cooler growing season—seasonal conditions which are not well adapted to the growing of corn.

In digestible dry matter per acre, corn, wherever it thrives, is assuredly the more economical crop—and it has other excellent features to commend it. Nevertheless, as has been pointed out, the growing of farm roots should not be altogether neglected, for in addition to their food value they contribute to the ration qualities which conspicuously make for thrift—qualities not possessed by any other class of forage crop.

Since corn has been referred to as the chief crop which in recent years has taken the place of farm roots, it will be of interest to follow up the comparison between these two succulent forage crops.

The following data present the average composition of these crops from the standpoint of feeding value.

—	Mangels	Indian corn (as cut for silo)
Water	88·9	76·9
Dry matter*	11·1	23·1
	100·0	100·0
*Crude protein	1·2	1·9
" fat	0·6	0·3
Carbohydrates	7·2	13·4
Fibre	0·9	5·9
Ash	1·2	1·6

Weight for weight, it will be observed that corn, purely from the feeding standpoint, is the superior forage; it contains a higher percentage of dry matter and is richer in protein and carbohydrates.

However, calculating the relative amounts of the digestible nutrients in the dry matter of these two forages, figures are obtained which clearly show the superior quality of the dry matter of the mangel. It contains higher percentages of digestible protein and carbohydrates—which latter in the case of mangels, it may be pointed out, is very largely cane sugar. In this connection Henry and Morrison in "Feeds and Feeding" say: "Since nearly 90 per cent of the dry matter in roots and only 66 per cent of that in well matured corn silage is digestible, one would expect the dry matter of roots to have somewhat the higher value."

The following table presents the data which support the contention respecting the superiority of the dry matter of mangels.

DIGESTIBLE NUTRIENTS IN 100 POUNDS OF DRY MATTER OF MANGELS AND CORN

—	Mangels	Corn
	p.c.	p.c.
Protein	8·5	5·2
Fat (ether extract)	1·1	2·8
Carbohydrates	68·1	61·6

It will be of interest to consider briefly the mineral matter or "ash" of mangels, for, as already mentioned, this crop possesses a certain virtue in stock feeding by reason of its rather notable saline content. The percentage of ash in mangels is somewhat less than that in corn but when calculated on the dry matter basis, mangels have the higher figure. The data are as follows:

MINERAL MATTER OR ASH IN 100 POUNDS OF DRY MATTER OF MANGELS AND CORN

—	Mangels	Corn
	p.c.	p.c.
Total ash*	10·8	6·9
*Containing—		
Lime (CaO)	0·67	0·74
Potash (K_2O)	5·72	2·50
Phosphoric acid (P_2O_5)	1·30	0·56

These results show that the dry matter of mangels as compared with that of corn, is richer in (1) total mineral matter, in (2) potash and (3) in phosphoric acid.

The chief constituents of the ash of mangels, as is evident from the above figures, are potash and phosphoric acid. The mildly medicinal effect of roots, their slightly laxative and diuretic properties are due very largely to their saline content. The functions and value of roots as a tonic and general " conditioner " are well recognized by experienced stockmen, who consider that they play an important part towards the maintenance of health and thrift.

It has already been stated that the feeding value of mangels depends on their dry-matter content and the richness of this dry matter is sugar. Mangels, in common with other farm roots differ in this respect; inherited qualities, size, seasonal conditions etc., are factors, all of which have their influence on sugar production and storage.

Sugar mangels, half-sugar mangels are of comparatively recent origin, they have resulted from the crossing of mangels and sugar beets. As a class they are richer in dry matter and sugar than ordinary mangels and as a rule give a higher yield.

The analysis of many varieties of mangels and sugar mangels grown at Ottawa over a number of seasons has shown wide ranges in feeding value.

The following table presents maxima, minima and averages of dry matter and sugar for mangels and sugar mangels, grown on the Central Farm, Ottawa during the past ten seasons.

DRY MATTER AND SUGAR IN MANGELS AND SUGAR MANGELS—1916–1925. C.E.F. OTTAWA

Year	Mangels							Sugar and Half Sugar Mangels						
	No. of varieties	Dry Matter			Sugar in Juice			No. of varieties	Dry Matter			Sugar in Juice		
		Maximum	Minimum	Average	Maximum	Minimum	Average		Maximum	Minimum	Average	Maximum	Minimum	Average
		p.c.	p.c.	p.c.	p.c.	p.c.	p.c.		p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
1916	32	11·39	6·24	9·37	6·37	0·92	2·94	3	10·37	8·21	9·46	5·18	2·05	3·53
1917	29	17·28	8·72	12·67	11·50	3·42	6·67	2	14·33	11·97	13·15	8·60	6·21	7·40
1918	11	13·76	9·73	11·75	7·82	2·84	6·04	2	12·10	11·71	11·91	6·61	6·62	6·62
1919	61	18·29	8·42	12·31	8·92	3·25	6·07	15	14·84	9·00	13·02	7·92	3·46	6·37
1920	33	11·87	6·64	8·89	7·17	2·46	4·29	9	12·40	8·05	10·24	6·09	4·28	5·26
1921	30	13·20	7·55	9·47	7·73	2·13	4·07	10	10·51	7·71	9·51	4·56	1·74	3·71
1922	29	15·50	11·02	12·83	8·20	3·46	5·87	14	14·94	11·81	13·33	7·53	5·24	6·71
1923	93	16·55	9·58	12·73	8·82	1·22	5·10	24	19·55	11·54	14·02	8·16	3·24	5·72
1924	115	15·04	6·53	10·22	7·96	1·03	4·19	25	14·06	7·75	11·30	8·05	2·86	5·42
1925	24	12·47	8·44	10·33	7·40	1·84	4·75	5	12·71	11·37	12·10	7·90	3·87	5·35

Although the samples examined include year by year certain new varieties, thus preventing any strict comparison, from the standpoint of seasonal influence on dry matter and sugar content, it is quite evident from the large number of varieties examined that the variations observed, must, in the main, be due to the character of the season. A warm, dry autumn seems to be the chief seasonal factor towards high sugar production, and, conversely, cool wet weather during the latter weeks of the season, though conducive to a heavy yield, is not favourable to a high dry matter and sugar content.

Considering the ten-year period recorded in the table, 457 samples of ordinary mangels and 109 of sugar and half sugar mangels, were analysed. The averages of the series are as follows:

—	Dry matter	Sugar in juice
	p.c.	p.c.
Mangels	11·17	4·88
Sugar and half sugar mangels	12·18	5·61

These data clearly indicate the higher feeding value of the so-called sugar mangels.

Too great dependence must not be placed on varietal names. In the course of this work over one hundred and fifty different names have appeared on our lists. It cannot be claimed that all these represent distinct and established varieties or sorts, since seedsmen are apt to rename for the purpose of advertisement, old and well known strains and this has led to the appearance in many instances of the same variety or strain under several different names.

With this in mind it will be of interest to record the names of those mangels which have most frequently taken the lead on the yearly lists in respect to dry matter and sugar content.

Mangels: Danish Sludstrup, Mammoth Long Red, Giant Yellow Intermediate, Gate Post, Golden Tankard.

Sugar and Half Sugar Mangels: Giant Half Sugar White, Half Sugar Mangel, Royal Giant Sugar, Giant Half Sugar Rose, Danish Improved Sugar.

INFLUENCE OF HEREDITY IN MANGELS

To ascertain how far the composition of mangels might be influenced by inherited or transmitted characters, two widely known and popular varieties of mangels—Gate Post and Yellow Globe—were selected for investigation in 1900. These varieties represent two distinct types and showed at the outset considerable differences in dry matter and sugar content. They proved to be among the richest and the poorest of all the varieties analysed.

These two mangels were grown annually for twenty years (1900-1919) side by side on the same soil and with the same culture on the Central Farm, Ottawa. By this procedure the influences incident to differences in soil and season were eliminated. Under these conditions the composition (dry matter and sugar) characteristic of each mangel might be attributed solely to inherited and transmitted qualities.

The following table presents the epitomized results for the twenty-year period.

DRY MATTER AND SUGAR IN GATE POST AND GIANT YELLOW GLOBE MANGELS, 1900–1919

Season of growth	Gate Post				Giant Yellow Globe			
	Average weight of one root		Dry matter	Sugar in juice	Average weight of one root		Dry matter	Sugar in juice
	lb.	oz.	p.c.	p.c.	lb.	oz.	p.c.	p.c.
1900	–	–	11·14	6·15	–	–	8·19	2·64
1901	2	9	9·41	4·15	3	3	9·10	4·08
1902	3	2	13·90	9·39	3	9	10·24	5·24
1903	3	3	12·93	7·38	3	13	10·89	6·17
1904	2	14	12·64	7·62	2	13	9·24	5·26
1905	2	13	12·07	6·83	3	12	8·64	3·55
1906	2	2	12·90	6·59	1	8	12·73	6·45
1907	3	10	12·53	7·25	2	7	10·78	6·34
1908	1	11	12·02	4·94	2	4	10·66	4·47
1909	3	14	11·82	6·64	3	7	10·95	5·82
1910	6	8	9·59	4·26	6	13	7·80	2·74
1911	2	11	10·04	3·86	3	1	6·66	1·85
1912	3	5	8·98	5·05	3	2	7·87	4·75
1913	3	5	10·98	6·27	2	15	8·90	5·18
1914	2	11	14·40	8·00	2	1	11·16	6·32
1915	2	15	11·41	4·15	2	12	8·21	3·31
1916	1	10	9·79	4·07	1	9	8·68	3·17
1917	1	13	14·24	7·41	2	–	11·39	5·89
1918	2	8	12·87	7·22	2	4	9·73	2·84
1919	–	11	15·50	9·40	–	14	10·68	5·50
Average for 20 years	2	3	11·95	6·33	2	13	9·62	4·57

In these results there is satisfactory evidence that distinct varieties are able to transmit in a marked degree qualities or characters as to composition.

Throughout the whole period, without a single exception, the Gate Post has proved the superior variety; results have varied from season to season and neither variety has exhibited any marked constancy in composition, indicating the influence of seasonal conditions, but invariably, the Gate Post has been the richer of the two.

The averages for the twenty-year period show that the Gate Post variety contains over 2 per cent more dry matter and nearly 2 per cent more sugar than Giant Yellow Globe—differences in feeding values of very considerable importance.

TURNIPS

Under this general term, for the present purposes, the composition of the Swede turnip or Rutabagas (*Brassica campestris*), as well as that of the turnip proper (*B. rapa*), will be discussed. The turnip crop as a whole, probably ranks next in importance to that of mangels.

Turnips thrive best under conditions which differ somewhat from those best suited to mangels. The latter for their development require moderately high summer temperatures whereas turnips are most successfully grown in districts characterized by comparatively cool summers and long, open falls, such as we find, for instance, in many parts of the Maritime Provinces.

For a study of the feeding value of turnips as derived from analysis the data for dry matter and sugar from the work of eight years in these laboratories may be presented. The turnips analysed were grown on the Central Experimental Farm, Ottawa, 1916-1924 (excepting 1921, when the crop was a complete failure)

and included both Swede and Fall varieties. The samples examined during this period numbered 409, and were representative of all well known varieties on the Canadian market. They, further, included a number from imported European seed. (For details see Annual Reports of Division of Chemistry, 1916-1924.)

DRY MATTER AND SUGAR IN TURNIPS, 1916–1924, C.E.F., OTTAWA

Year	Number of varieties	Dry Matter			Sugar in Juice		
		Maximum	Minimum	Average	Maximum	Minimum	Average
		p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
1916	28	12·80	9·53	10·67	2·46	0·51	0·92
1917	59	13·59	9·29	11·04	2·16	1·10	1·41
1918	16	12·62	10·12	11·18	3·02	0·61	1·06
1919	93	16·48	9·46	12·10	1·72	0·82	1·11
1920	22	14·00	10·09	12·60	2·23	1·51	1·84
1922	41	13·58	9·80	11·46	1·73	0·91	1·09
1923	126	15·93	8·29	11·22	1·23	0·20	0·61
1924	24	12·35	9·83	10·61	2·36	0·61	0·94
Average				11·42			0·99

Comparing these results with similar data from mangels, it will be observed that in both dry matter and sugar turnips show a smaller range (*a*) between varieties as shown by the smaller " spread " between maxima and minima data and (*b*) from season to season. Expressed otherwise, turnips show a much greater constancy in composition than mangels, varietal and seasonal influences being less potent with the latter crop.

In respect to dry matter (which to a large degree measures the feeding value), *average* data for mangels and turnips have not differed greatly when obtained from results over long periods and including many varieties. However, as the detailed data show, the better varieties of mangels usually far exceed the best turnips.

In sugar, which as already pointed out, is the most important nutrient in roots, turnips are much inferior to mangels; averages from results at Ottawa give a sugar content to mangels of almost five times that of turnips—which is usually in the neighbourhood of one per cent.

The percentage of ash in turnips is somewhat less than that in mangels; the more important data are as follows:—

TURNIPS: MINERAL MATTER OR ASH IN 100 POUNDS OF DRY MATTER

	p.c.
Total ash*	9·47
*Containing—	
Lime (CaO)	1·00
Potash (K_2O)	4·30
Phosphoric acid (P_2O_5)	1·19

In the year 1922 the data of the Swede (Rutabagas) and of the Fall turnip were presented in separate tables. For the purposes of comparison the following averages are here given.

	Swedes or Rutabagas		Fall Turnips	
	41 varieties		24 varieties	
	Dry matter	Sugar in juice	Dry matter	Sugar in juice
	p.c.	p.c.	p.c.	p.c.
Maximum	13·58	1·73	11·95	1·23
Minimum	9·80	0·91	8·02	0·41
Average	11·46	1·10	10·14	0·80

From these data it would appear that the Swede is decidedly richer than the Fall turnip in dry matter and also, though to a less degree, in sugar. The Swede or Rutabaga is more generally grown, is earlier, has better keeping qualities, and gives higher yields than the fall turnip.

FERTILIZERS FOR THE TURNIP CROP

The fertilizing of the turnip crop has for a great number of years received special attention in Great Britain. It has been found that this crop responds particularly well to applications of phosphoric acid, which element of plant food favours root development and improves quality. Turnips, as a rule, require a cool, damp climate, and under such conditions may be supplied with fairly heavy applications of plant food, with profit. Under more or less dry conditions the yield may often be limited by the moisture supply, and in these circumstances a small to moderate application of fertilizer will usually be found the most profitable. While the turnip crop responds in a very marked degree to an application of phosphoric acid, the addition of small quantities of a nitrogenous and potassic fertilizer in the manurial treatment will usually be found advantageous; it has been found that fertilizer dressings have been particularly useful in forcing the development of this crop in the earlier stages of growth and thus in a very large measure furnishing protection against the attacks of injurious insects.

Commercial fertilizers will, in most cases, give best results when applied in conjunction with a dressing of barnyard manure. They may be applied broadcast or as a side dressing at planting time, but undoubtedly the safest and best results are obtained when the fertilizer is applied some little time—a few days—previous to planting and thoroughly incorporated with the soil to ensure diffusion in the soil.

The kind and quantity of fertilizer which may be recommended for the turnip crop will depend on the character and fertility of the soil. On average loams which have been dressed with 8 to 10 tons of manure, an application of from 300 to 500 pounds of superphosphate per acre may be found sufficient, or the following mixture may be recommended:—

Nitrate of soda	100 to 150 lb.
Superphosphate	300 to 500 lb. per acre
Muriate of potash	30 to 50 lb.

equivalent to 500 and 750 pounds per acre of a 3-10-3 mixed fertilizer.

When the crop is liable to an attack of "club-root" the soil should be dressed with lime previously, or if this cannot be done, the superphosphate may be replaced with advantage by an equal quantity of basic slag. When a dressing of manure is given, the danger of club-root development may also be lessened if the manure is applied the preceding autumn. Drying out of the soil will also be lessened by its fall application.

CARROTS

Though with rich and suitable soil and with favourable seasonal conditions good yields may be obtained, carrots are to be regarded as a garden rather than as a field crop. Carrots have a reputation as an appetizer and have been chiefly used for horses, which relish them greatly. They have also been fed satisfactorily to other stock, especially sheep and dairy cows. The colouring matter of red carrots is carotine, and it would seem reasonable to conclude that

the feeding of such carrots to milking cows on winter rations would enhance or deepen the colour of their butter-fat, since the colouring matter in both is the same pigment.*

As with mangels and turnips, the Division of Chemistry has for a number of years past analysed representative roots of the more important varieties of carrots grown on the Central Farm, Ottawa. In the following table we present the data for nine years (1916-1924), comprising figures for maxima, minima, and averages for dry matter and sugar in juice. The number of samples analysed was 208 and included practically all the varieties on the market in addition to a few specially imported strains.

DRY MATTER AND SUGAR IN CARROTS, 1916-1924, C.E.F., OTTAWA

Year	Number of varieties	Dry Matter			Sugar in Juice		
		Maximum	Minimum	Average	Maximum	Minimum	Average
		p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
1916	10	13·75	9·48	11·40	4·93	1·83	2·87
1917	13	15·55	11·19	12·69	3·73	2·33	2·92
1918	3*	13·37	11·43	12·13	5·87	5·02	5·30
1919	36	16·56	8·68	12·04	4·01	1·73	2·79
1920	15	11·22	7·53	9·48	3·05	1·23	2·25
1921	13	12·09	7·95	9·78	3·43	1·42	2·23
1922	23	14·74	10·39	12·04	4·12	1·32	2·28
1923	49	18·01	10·35	12·67	3·98	1·21	2·43
1924	46	15·45	9·37	10·92	6·04	1·21	2·75
Average				11·61			2·52

* Omitted in calculating the averages, the data being exceptionally high; very small roots extremely rich in sugar resulted from somewhat unusual cultural and seasonal conditions.

There is a greater constancy in respect to dry matter than is to be observed among varieties of mangels; in other words, the differences between the richest and poorest varieties is not so large as in mangels. In this constituent (dry matter) carrots occupy a place about midway between the highest and lowest of mangels.

In sugar, carrots, while richer than turnips, are much poorer than mangels; the ratio for turnips, carrots, and mangels would be practically 1:2.5:5.

In the following table data for dry matter—its percentage and composition—for the three classes of farm roots are presented.

MANGELS, TURNIPS, CARROTS—DRY MATTER: COMPOSITION AND DRY MATTER PER TON (AVERAGES)

Farm roots	Water	Dry matter	Composition of Dry Matter					Dry matter per ton
			Protein	Fat (ether extract)	Carbo-hydrates	Fibre	Ash	
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	lb.
Mangels	88·83	11·17	10·83	0·28	68·06	8·72	11·33	223
Turnips	88·58	11·42	10·47	0·52	68·31	13·40	7·30	228
Carrots	88·39	11·61	7·73	0·21	72·88	9·81	9·37	232

Summarizing the characteristics of farm roots—mangels, turnips, and carrots—as discussed in this bulletin, they are to be regarded as succulent, palatable, highly digestive nutritious forage crops, possessing in addition to their nutritive value, qualities and properties which promote good health and make for thrift.

* Feeding experiments conducted by Palmer and Eckles, of the Dairy Chemistry Laboratory, University of Missouri, definitely showed that if food rich in carotine, e.g. carrots, were fed to cows the milk-fat of which had become practically colourless, the milk-fat will increase in colour.

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